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December 22, 1982

C1820/WJT/AW

Department Energy Mines & Resources,
CANMET, Energy Research Laboratories,
555 Booth Street,
Ottawa, Ontario
K1A 0G1

CONTRACT REPORT NO. OSQ82-00104

Attention: Mr. A.C.S. Hayden

Gentlemen:

Re: Enersolve Demonstration Project:
Boiler Operations at Rio Algom's Panel Mine

We are pleased to submit our report on energy conservation improvements associated with boiler operations at Rio Algom's Panel Mine.

Your references are:

CANMET PROJECT NO: 410103

DSS FILE NO. 17SQ.23440-2-9055-1

We will be submitting our invoice shortly.

Thank you for the opportunity to work with you and your group on this project.

Yours very truly,
SIMON-CARVES OF CANADA LTD.

W.J. Thoburn

W.J. Thoburn, P. Eng., Ph.D.,
Technical Manager -
Mining & Metallurgy

FEB 28 1984
MICROMEDIA

cc:
Mrs. Paula Green (DSS)

46 pp

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PRE-ENGINEERING ASSESSMENT OF AN ENERSOLVE DEMONSTRATION PROJECT AT RIO ALGOM'S PANEL MINE

Final Report

December 21, 1982

Project No. C1820

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Work on this project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology Energy Mines and Resources, Canada.

DSS File No. 17SQ.23440-2-9055-1

Canmet Project No. 410103

WP9C-1

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SECTION 1

INTRODUCTION

1.1 BACKGROUND

On September 15, 1982, Simon-Carves was awarded a contract from Supply and Services Canada to assess one of the boiler operations at Rio Algom's Panel Mine and thereafter recommend efficiency improvements. This project was one of a number of pre-engineering assessments undertaken across Canada in the Enersolve Demonstration Projects program. The DSS file number was 17SQ.23440-2-9055-1 for this study of the Panel Mine boiler.

The contents herein comprise the final report requested by December 31, 1982.

1.2 SCOPE

The existing Panel Mine boiler operation is described in sufficient detail to permit a conceptual evaluation of energy conservation improvements and corresponding costs in the range of plus or minus 25%.

Information is presented for operations during October 1982 when field measurements were taken. As well, comparisons are projected where necessary for operations at the maximum steam production rate normally occurring in the coldest winter months.

1.3 STRATEGY AND METHODOLOGY

Our basic strategy has been to procure as much recent and historical operating data as possible from Rio Algom and utilize our experience to evaluate this information. To clarify any omissions, a program of field measurements was initiated.

SECTION 1

INTRODUCTION

1.3 STRATEGY AND METHODOLOGY

From the available data, metallurgical balances were constructed. Following this, various improvement options were considered and corresponding costs estimated. The cost/benefit and payback period aspects of the options considered were completed on the basis of the cost estimates.

SECTION 2

SUMMARY & RECOMMENDATIONS

Rio Algom currently operates a number of underground and surface processing facilities near Elliot Lake, Ontario. One of the operations is Panel Mine. Steam used at Panel Mine is produced in four bunker C oil fired boilers.

The unit investigated in this study is one of three having a nominal steam generation capacity of 22,000 lb/hr. The fourth unit, a slightly larger rental boiler, was installed in June 1982.

A conversion program was undertaken in 1977 to modify the three 1940 vintage units from coal to oil. Programs have recently been initiated to assess the efficiency of these boilers. Steam and heat conservation schemes have been completed and are developing for other aspects of the operation.

In October 1982, as part of this project, one of the three 22,000 lb/hr boilers was investigated and available operating data collected. Based on the information obtained and the thermal balance subsequently constructed, a boiler efficiency of 82% was estimated.

A number of energy use efficiency improvements were considered based on the boiler operating parameters documented. As the Panel Mine projected operating life has been estimated to be in the range of eight to ten years, economic analyses supporting the proposed improvements were considered attractive if payback periods were four years or less. Longer payback periods were considered unattractive. All benefit/cost ratios were calculated for four years of operation.

Table 2.1 summarizes the eight efficiency improvement possibilities. After preliminary assessments, three of the eight schemes were discarded for the following reasons:

TABLE 2.1

SUMMARY OF POSSIBLE BOILER EFFICIENCY IMPROVEMENTS

	Improvement Description	Principal Equipment Required	Installed Capital Cost $ Thousands	Payback Period Months	Benefit/Cost**
1.	Boiler Feed Water Economizer	Water/Gas Heat Exchanger	90	23	1.70
2.	Elimination of Steam Heat Circuits	Alternate Local Heating Installations	300	*	-
3.	Oil Tank Farm Heating Condensate Recovery	Condensate Recovery Vessel	32	29	1.23
4.	Insulation of Pachuca Tanks	New Insulation	174	29	1.24
5.	Up-dated Boiler Controls	New Instrumentation	25	(52)	0.89
6.	Pachuca Heating Method	Steam/Air Heat Exchanger	not practical*	-	-
7.	Burner Up-graded	New Burner	39	(58)	0.89
8.	Combustion Air Preheating	Air Heat Exchanger for Combustion System	not practical*	-	-

*See text for explanation and Section 5 for details.

**Benefit/Cost = $\frac{\text{Present Value of After Tax Savings After Four Years}}{\text{Capital Investment}}$

SECTION 2

SUMMARY & RECOMMENDATIONS

Option 2 Elimination of Steam Heat Circuits

Remote steam use locations are currently serviced with pipelines insulated a number of years ago. Even though the efficiency of steam heat for this application may be questionable, alternate heating by propane suffers from large capital investment and operating costs. Bunker C oil remains the cheapest of the common industrial fuels available to Panel Mine.

Option 6 Pachuca Tank Heating

Pachuca tank heating is currently accomplished by direct steam injection. Various alternatives including indirect heating and steam heated air were assessed as unsatisfactory. It was concluded improved condensate recovery is not viable with the Pachuca tanks in their existing form.

Option 8 Combustion Air Preheating

Although combustion air preheating can be readily achieved through extraction of heat from exhaust gases, utilization of the heated air is not straightforward. Operating temperature limitations preclude use of the existing combustion air fan. The burner throat was designed for ambient temperatures and would exhibit an unacceptably high pressure drop with preheated air. Given the major changes involved with preheated air, the new burner option should be considered a more promising alternative.

SECTION 2

SUMMARY & RECOMMENDATIONS

The more attractive options outlined in Table 2.1 include:

Option 1 Boiler Feedwater Economizer

Recovery of heat from the exhaust gases can readily be accomplished with an economizer inserted into the common exhaust flue feeding the boilerhouse stack. The increased feedwater temperature and resulting fuel savings yields the shortest payback period of 23 months and highest benefit cost ratio of 1.7 of all the options considered.

Option 3 Tank Farm Heating Condensate Recovery

Condensate formed in steam coils used to heat the Bunker C oil storage tanks is presently sewered. Installation of a condensate reclaim vessel designed to prevent any possible oil leaks mixing into boiler feedwater shows a payback period of 29 months and a 1.23 benefit/cost ratio.

Option 4 Insulation of Pachuca Tanks

The Panel Mine Concentrator normally operates twelve Pachuca tanks n their leaching circuits. At present none are insulated. Adding insulation is complicated by the build-up in the tanks, however, sufficient information is available to permit an estimate of insulation requirements.

Fuel savings from heat loss reductions including compensation for sanded-out tanks yields a payback period of 29 months and a benefit/cost ratio of 1.24.

SECTION 2

SUMMARY & RECOMMENDATIONS

The less attractive options having payback periods exceeding four years are the following:

Option 5 Up-dated Boiler Controls

Currently the boiler electro-mechanical controls operate according to steam drum pressure. To bring the combustion control system up-to-date requires replacement of the mechanical linkage and drives with new sensors and drivers on fuel, air and atomizing steam valves. The cost of this package is about $25,000 and results in small fuel savings which yield a payback of 52 months and a benefit/cost ratio of 0.89.

Option 7 New Burner

The existing register type boiler burners installed at Panel Mine operate with a minimum of 15 to 20 percent excess air. A new axial flow, skewjet atomizer burner could be installed to reduce the excess air to 5%. With this improvement and reduced ingress air through a lower boiler combustion chamber draft, the fuel savings would pay for the installation in 58 months with a benefit/cost ratio of 0.89.

The economizer described in Option 1 shows the best return on investment. The payback period is less than two years making it an attractive improvement when evaluated over a short term period. Rapid increases in fuel prices over the next few years will make the economizer option all the more attractive. An economizer will produce a respectible return on investment should more efficient boilers or burners be installed in the near future. This reflects the short payback period and the viability of an economizer complimenting a more efficient boiler operation.

SECTION 2

SUMMARY & RECOMMENDATIONS

Insulation of Pachuca tanks and recovery of condensate from tank farm heating circuits reduce fuel consumption through conservation and should be considered in any efficiency improvement program.

The cost shown in Table 2-1 includes estimates for engineering. Nine month monitoring programs to evaluate the benefits of introducing various options is shown in Table 2.2.

The capital costs in Table 2-1 include start-up or commissioning costs, where applicable, sufficient to ensure the equipment is functioning properly. A nine-month monitoring program with costs shown in Table 2-2, including a series of accurate measurements to quantify the performance of up-graded equipment, would not normally be found in a retrofit program.

By combining options, for example, Options 1, 3 and 4, the monitoring cost would be reduced since a single evaluation program and report covering the three items would be produced.

TABLE 2.2

SUMMARY OF MONITORING PROGRAM

COSTS TO EVALUATE FUEL CONSERVATION

AND BOILER EFFICIENCY OPTIONS*

Option	Improvement Description	$ Nine Month Monitoring Program
1	Economizer	18,650
3	Oil Tank Farm Heating Condensate Recovery	9,280
4	Insulation of Pachuca Tanks	13,900
5	Burner Up-Graded	18,650

SECTION 3

DESCRIPTION OF EXISTING FACILITIES

3.1 INTRODUCTION

The Elliot Lake area operations of Rio Algom Limited include three mines and three concentrators currently in operation or under construction. Panel Mine, located 25 km north of the Elliot Lake townsite, is one of the three surface processing facilities.

The common practice at Panel Mine is to employ steam for a variety of jobs in the surface operations. These range from building space heating to process heating and agitation in acid leaching Pachuca Tanks. Demand fluctuations are principally seasonal.

Steam generated in one boiler house is routed to the various users. Condensate is recovered wherever possible.

3.2 DESIGN STEAM DEMAND AND GENERATION CAPACITY

Steam requirements at Panel Mine were designed such that half the production served acid leaching and other process circuits in the mill. The original design distribution is summarized in Table 3.2.1.

To provide the needed steam, Panel Mine has operated three boilers nominally rated at 22,000 lb/hr of steam. To meet peak loads in winter, operating rates were extended to 125% of the nominal values. In order to provide a stable steam supply and some outage capacity, a fourth Foster Wheeler boiler, rated at about 30,000 lb/hr, was rented and installed in June 1982.

The three original boilers are circa 1940 coal fire design. Conversion(1) to oil firing was undertaken in 1977. Bunker C oil has been used since the retrofit to the present time. Table 3.2.2 summarizes the boiler characteristics and Fig. 3.2.1 outlines a simplified version of the steam plant flowsheet.

TABLE 3.2.1

SUMMARY OF DESIGN STEAM DEMAND AND DISTRIBUTION

Area	Use	Steam Demand lb/hr		Condensate lb/hr
Concentrator	Leaching and Process Heat	39,100		32,038
Concentrator	Bldg. Heat	21,900		
Crusher House and Trade Shops	Equipment and Space Heating	17,280		16,180
	Sub-Total		78,280	
Boiler House Internal Use (estimate)	Oil Heating, atomization, water deaeration	5,000		2,000
	TOTAL	83,280		50,218

TABLE 3.2.2

CHARACTERISTICS OF PANEL MINE

22,000 LB/HR BOILERS

Item	Boiler Description
Original	
Make	Foster Wheeler
Model	SG80-236
Current	
Nominal Steam Production	22,000 lb/hr
Boiler Horsepower	316.5
Approximate Turndown	4/1
Nominal Heat Input	27.7×10^6 BTU/hr
Total Heating Surface	3165 $ft.^2$
Boiler Operating Pressure	125 psig
Boiler Design Pressure	206.7 psig
Boiler Design Steam Temperature	353°F
Boiler Feedwater	212°F
Boiler Tubes	2½" O.D. 12 GA.
Oil Burner	Todd CEA D16
Fuel Oil Pressure Max.	90 psig
No. 6 Fuel Oil Feed Rate Max.	1518 lb/hr
Oil Atomizing Steam (est.)	0.15 lb/lb oil

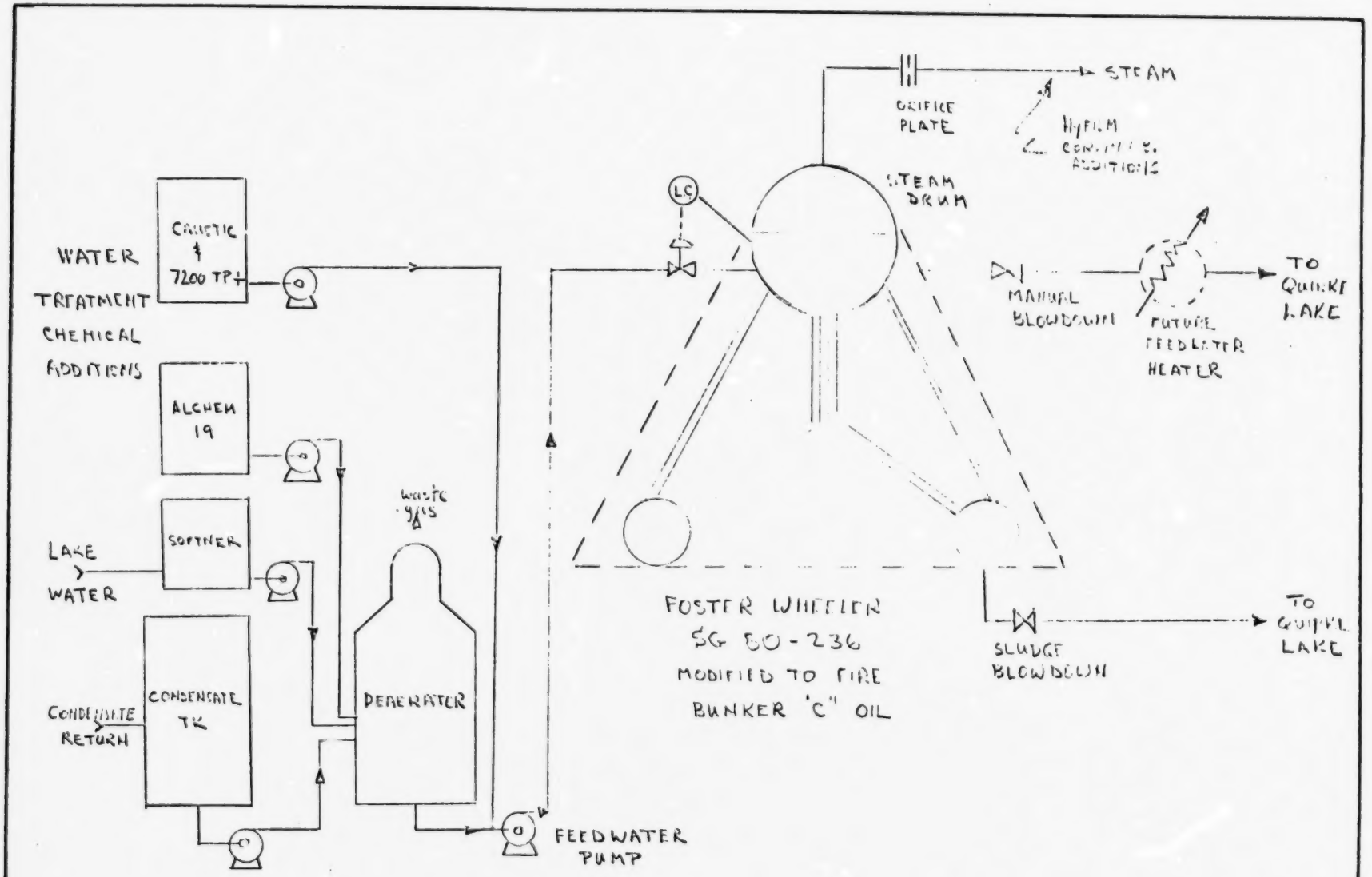

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FIG. 3.2.1 PANEL MINE BOILER FLOWSHEET

SECTION 3

DESCRIPTION OF EXISTING FACILITIES

Boiler fuel, stored in four 25,000 I. Gal. insulated, vertical tanks, is maintained at temperature by unregulated steam heat. Condensate from the tank farm heating system is sewered. Table B1 in Appendix B summarizes the characteristics of the fuel currently used at Panel Mine.

Steam from the boilerhouse is piped about 46 m to the concentrator building and 300 m to serve a crushing facility and maintenance shops.

SECTION 4

MATERIAL AND THERMAL BALANCES AND BOILER EFFICIENCY ESTIMATE

4.1 BOILER BALANCES

Boiler operations were investigated and characterized October 13 and 14, 1982 in order to construct a thermal balance and estimate a boiler efficiency. Boiler operations were restricted to approximately 60% of design capacity during the data collection period. Raw data provided by operators at the Panel Mine boilerhouse are shown in Table 4.1.1

Based on the October findings, and fuel consumption and steam generation during 1981 shown in Appendix C, the heat balance outlined in Fig. 4.1.1 was constructed. In order to have a balance free of unaccounted factors to permit subsequent economic analyses, a number of assumptions shown in Table 4.1.1 were included.

In forcing the balance to close, an unaccounted surplus output heat of about 8% of the input was eliminated. This illustrates the accuracy of the balance based on the as received data. Given the short periods over which boiler observations were made, the unmodified heat balance is considered fairly accurate. The modified balance can be considered a convenient model for economic forecasting.

TABLE 4.1.1. ENERSOLVE PROJECT DATA: #3 BOILER PANEL MINE

TRIAL		FUEL			COMBUSTION AIR				FUEL VAPOURIZING STEAM			EXHAUST GASES (2)						STEAM			BOILER WATER								
													VOLUME %								FEED			MAKE-UP			BLOWDOWN		
No.	Date	kg/hr	°C	kPa	kg/hr	°C	kPa	RH %	kg/hr	°C	psig	°C	H_2O	CO_2	CO	O_2	$Nm^3/hr.$	kg/hr	°C	psig	kg/hr	°C	psig	kg/hr	°C		kg/hr	°C	kPa
1	13/10	315.4	89	20	-	21	atm	75			35	189	0	4.5	-	15	-	5880	175	115	6350	109	215				470		
					-																								
2	13/10	-	89	35	-	21	atm	75			49	206	0	6.0 9.0	-	14. 13.5		-	175	115	-	109	215				-		
					-																								
3	14/110	383.3	98	38	-	21	atm	75			51	196	0	6.5	-	10		6280	175	115	6782	104	212				502		
					-																								
4	14/10	301.3	98	37	-	21	atm	75			50	204	0	5.0	-	12.2		5114	175	115	5523	102	215				409		
avg.		333.3										199				12.9		5758		115	62.8	107					460		

(2) Draft 0.5# wg.

(1)-from steam drum
-assumed 8%

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Fig 4.1.1. HEAT BALANCE: ENERSOLVE DEMONSTRATION PROJECT DATE: October 19, 1982

SYSTEM: Panel Mine Boiler No. 3 REF. TEMP: 25°C (298°K)

ASSUMPTIONS/CHOICES: Oil : API 21° REF. PRESS. 1 atm.

MATERIALS AND BALANCE ITEMS	MASS RATE kg/hr	Cp or ΔH Δ H Kcal/kg Cp Kcal/kg	T °C	THERMAL DISTRIBUTION M cal PER hr	% OF INPUT
IN					
(N.H.) Fuel Comb.	358.7	9,994.2	-	3,585	86.4
Sens ht. Comb. Air	-		25	0	-
Sens ht. Vap. Steam	60	637	175	38	0.9
Sens ht. Feedwater	6152	83	107	511	12.3
Sens heat in fuel	374	35	94	13	0.3
Tramp Air	-		25	0	-
TOTAL				4,147	100
OUT					
Steam	5697	637	175	3,629	87.5
Exhaust Gases:					
N_2	6938	44	199	305	
CO_2	1110	37	199	41	9.9
O_2	979	37	199	36	
H_2O	345	79	199	17	
SO_2	7	28	199	-	
Shell Losses 1%				40	1
Unaccounted					-
Blowdown 8%	456	152	175	69	1.6
TOTAL				4,147	100

TABLE 4.1.1

ASSUMPTIONS USED TO FORCE HEAT BALANCE TO CLOSE

Heat Balance assumptions are:

i) That steam production measured with an orifice plate can be taken to be most accurate data for the heat balance.

ii) Blowdown from the steam drum is 8% of the feedwater.

iii) Shell heat losses are 1% of the heat input which is consistent with current boiler design practice.

iv) Fuel metering over short periods is probably less accurate than the steam production data. Hence, it can be assumed the annual average steam/oil ratio for 1981 is a better figure.

v) An excess air of 25% over combustion requirements. Support for this is derived from burner operating characteristics.(7)

vi) That ingress air into the combustion chamber can be adjusted to force the balance to close. Using this technique the calculated off-gas $C0_2$ content is within 15% of the average measured value.

SECTION 4

MATERIAL AND THERMAL BALANCES AND BOILER EFFICIENCY ESTIMATE

4.2 BOILER EFFICIENCY

Two measurements of boiler efficiency can be calculated. A simple estimate yields:

$$\frac{\text{heat in steam}}{\text{total heat input}} = 87.5\%$$

However, it is common practice to use a more comprehensive calculation technique. The North American standard method entails removing heat in the feedwater and use of the fuel gross heating value. (The European convention utilizes the net heating value). On this basis the standard North American boiler efficiency is calculated as:

$$\frac{\text{(heat in steam) - (heat in feedwater)}}{\text{fuel rate x gross heating value}} = 82.3\%$$

The efficiency calculated is considered qualitatively typical[1] or characteristic of the type of boiler currently operating at Panel Mine.

SECTION 5

EFFICIENCY IMPROVEMENTS AND ECONOMIC ANALYSES

5.1 INTRODUCTION

Evaluation of boiler operations and steam utilization at Panel Mine resulted in eight possible methods of increasing efficiency and reducing costs. The concepts ranged from boiler modifications to the elimination of certain steam heating circuits and the substitution of alternate energy sources. It was possible to discard some of the concepts at an early stage in the evaluation process. These options were considered impractical due to technical complications and hence detailed economic analyses were not carried out. All options have been presented in the discussion which follows to ensure the unfavourable evaluations are not re-assessed unnecessarily and reasons for rejection are made clear.

Cost data obtained from suppliers or in-house sources were used to compile capital and operating costs. To complete estimates of payback period or benefit/cost ratios, the economic factors shown in Table 5.1.1 were employed.

TABLE 5.1.1

SUMMARY OF ECONOMIC FACTORS USED IN

EFFICIENCY IMPROVEMENT COMPARISONS

	Item	Estimated Value
	Investment Interest Rate	12%
	Annual Escalations**	
i)	Bunker C	14.3%
ii)	No. 2 Oil	12.1%
	Time Period	4 years
	Income Tax Rate	50%
	Depreciation Rates	
i)	Process items*	50%
ii)	Building and other	5%

*including insulation on process equipment - Can. Master Tax Guide 1982, p. 236

**data from Ontario Ministry of Energy for fuels up to the end of 1987

SECTION 5

EFFICIENCY IMPROVEMENTS AND ECONOMIC ANALYSES

5.2 OPTION 1 - BOILER FEEDWATER ECONOMIZER

Off-gas temperatures measured in the exhaust flue from No. 3 boiler ranged from 189 to 206°C in October 1982. Heat in the exhaust gases fuels the economizer operation.

To maximize heat recovery, an economizer would best be inserted in the common exhaust flue feeding the boilerhouse stack. The principal concerns with such an installation would be fly ash plugging and gas side acid condensate. With an outside installation, a fail-safe drain technique would be needed to ensure protection from freezing conditions.

Heat recovery programs at Panel Mine typically increase the raw feedwater temperature to 49°C coming to the boilerhouse. Discharging from the deareator, water is 107°C. It is from this point feedwater would be fed to the economizer, mainly to minimize condensation corrosion. The economizer system would increase the feedwater temperature to approximately 124°C. The improvement is equivalent to a fuel saving of 282,200 kg/year of oil.

Table 5.2.1 shows the economic analysis supporting the economizer installation. The benefit/cost ratio and payback period are 1.7 and 23 months respectively.

Performance of the economizer is based on current operations. However higher exhaust gas temperatures are expected if the draft was reduced from the current value of 1.3 cm W.G. to 0.25 in. W.G. Mass and thermal balances discussed in Section 4 showed ingress air leaking into the combustion compartment as high as 50 percent of the combustion air rate. Reducing the draft should significantly reduce the dilution[4] of exhaust gas with tramp air and increase the temperature of exhaust gases available for boiler feedwater preheating. This would also result in a larger dew point safety margin. A program to check all boilers and carry out leak repairs could also be instituted to increase the exhaust gas temperature. The cost of such a program was not included in Option 1.

TABLE 5.2.1

ECONOMIC EVALUATION OF AN ECONOMIZER INSTALLATION AT PANEL MINE

Year	Capital Investment	Fuel Saving	Cap. Cost Allowance	Taxable Income	Tax 50%	Cash Flow	Annual Present Value	Total N.P.V.
0	90,000	-	-	-	-	-90,000	-90,000	-90,000
1	-	62,614	45,000	17,614	8,807	53,807	48,050	-41,950
2	-	71,568	45,000	26,568	13,284	58,284	46,452	+4,502
3	-	81,802		81,802	40,900	40,900	29,122	33,624
4	-	93,500	-	93,500	46,750	46,750	29,733	+63,357

Note: Payback Period 23 months on the installed cost.

Benefit/Cost = 153,357/90000 = 1.70

*N.P.V. = net present value

SECTION 5

EFFICIENCY IMPROVEMENTS AND ECONOMIC ANALYSES

5.3 OPTION 2 - ELIMINATION OF STEAM HEAT CIRCUITS

The general arrangement of buildings at Panel Mine results in a 300 m run of insulated steam and condensate lines from the boilerhouse to a crushing plant and associated maintenance shops. Steam supplied to this area is used for process or space heating. Alternate heating methods, utilizing local units fuelled with propane or No. 2 oil could be considered and in so doing about 22% of the steam generation requirement would be eliminated. The design steam distribution was outlined in Table 3.2.1.

For this analysis, it is proposed that 100% of the former steam heating be supplied by propane radiant heaters for process and space heating applications. Light oil heating methods would also be evaluated as an alternative to propane if a more detailed evaluation were carried out.

Steam normally supplied to the crushing plant and shops is equivalent to 20×10^6 BTU/hr (5×10^6 Kcal/hr) at the design load. Oil for this service, assuming the average yearly demand is 70% of the design, costs $571,500/yr. Elimination of steam for the above heating circuits reduces approximately 48×10^6 kg/year of Bunker C oil, from Panel Mine's fuel bill.

Propane heaters are estimated to cost $300,000[11] installed to achieve the equivalent heating. This includes an anticipated improvement of 20% due to the availability of more efficient heating systems and the elimination of steam transmission losses. Propane fuel for the heaters, averaging 70% of the design load, totals $\$1.14 \times 10^6$ per year. A cost differential of about $0.13/lb. of fuel favours the existing bunker C steam heating methods. The combination of large capital investment and high cost of propane precludes further work being carried out on this option.

SECTION 5

EFFICIENCY IMPROVEMENTS AND ECONOMIC ANALYSES

5.4 OPTION 3 - OIL TANK FARM HEATING - CONDENSATE RECOVERY

Boiler design practice, as a rule, discourages condensate formed in oil storage vessel heating circuits from returning directly to the boiler feedwater circuit. The Panel Mine oil tank farm is currently heated by unregulated steam. Condensate produced is sewered generating a boiler feedwater water loss estimated to be 910 kg/hr or 8×10^6 kg/yr.

One possible method of recovering the condensate and heat content requires a steam to water or glycol solution heat exchanger to satisfactorily separate the two systems. For simplicity it is assumed the change of heating medium will not adversely affect the oil heating process making this a potentially workable scheme.

A second somewhat simpler reclaim method requires the installation of a condensate collection vessel. This unit vents flashing losses to atmosphere and has a sighting/skimming system to eliminate possible oil contamination of the boiler feedwater. The feedwater return pump takes suction from the vessel bottom. A condensor may be required to treat the exhaust gases but has not been included in this version. Fig. 5.4.1 shows a sketch of the condensate recovery vessel.

This second scheme is generally more attractive and if implemented would result in a savings of 1.19×10^6 kg of Bunker C oil per year. Cost of the installed vessel and ancillaries is estimated to total $32,300.00.

Table 5.4.1 shows the economic analysis supporting the tank farm heating retrofit option. The benefit/cost ratio and payback periods are 1.23 and 29 months respectively.

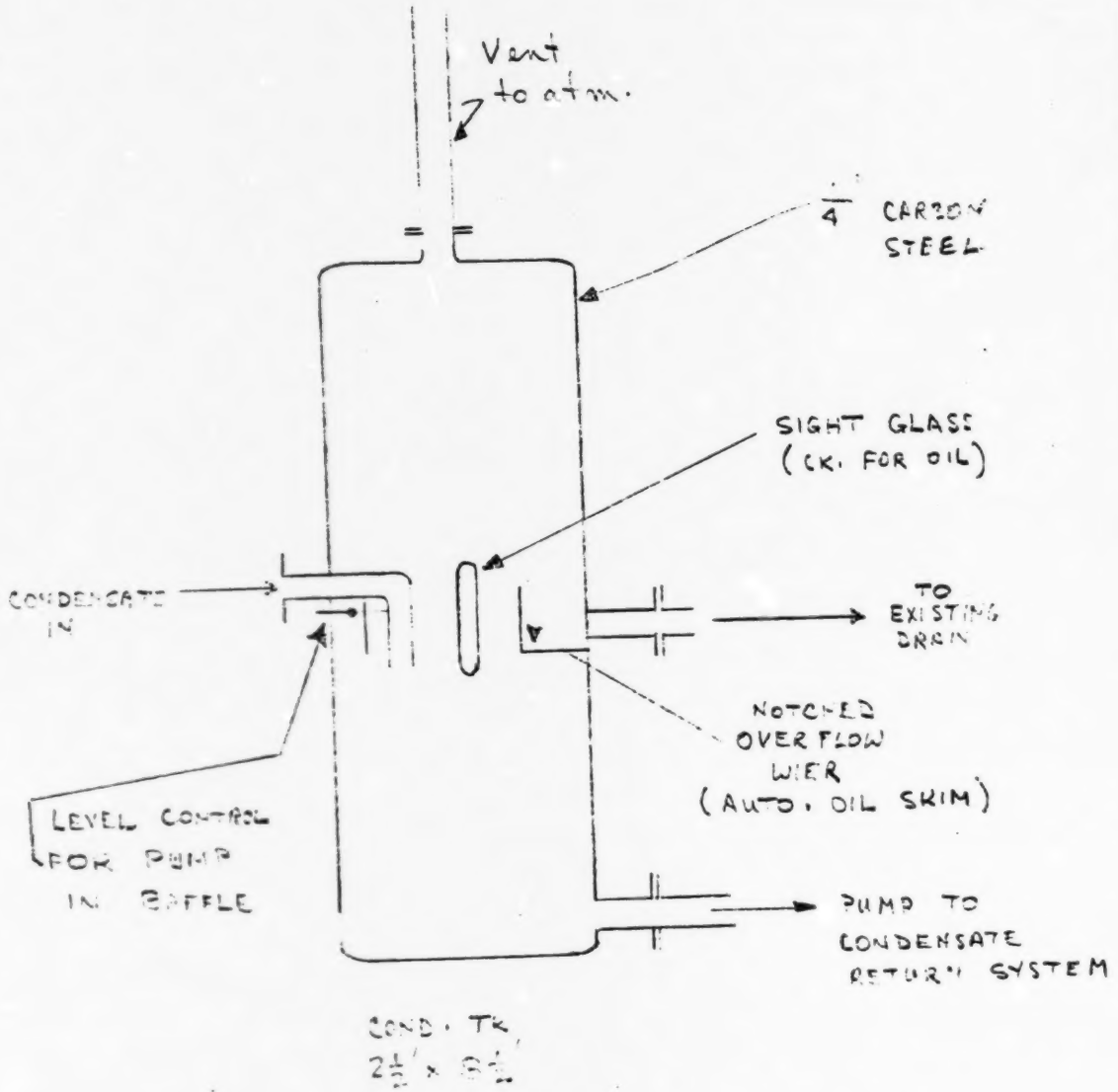

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FIG. 5.4.1 TK FARM STEAM CONDENSATE RECOVERY VESSEL

TABLE 5.4.1

ECONOMIC EVALUATION OF OIL TANK

FARM HEATING STEAM CONDENSATE RECOVERY

Year	Capital Investment	Fuel Saving	Cap. Cost Allowance	Taxable Income	Tax 50%	Cash Flow	Annual Present Value	Total N.P.V.
0	32,300	-	-	-	-	-32,300	-32,300	-32,300
1	-	14,200	14,200	0	0	14,200	12,681	-19,619
2	-	16,231	16,231	0	0	16,231	12,936	-6,683
3	-	18,551	1,869	16,682	8,341	10,210	7,270	+587
4	-	21,204	-	21,204	10,602	10,602	6,743	7,330

Note: 1 Payback 29 months
2 Benefit/Cost = 39,630/32,300 = 1.23

SECTION 5

EFFICIENCY IMPROVEMENTS AND ECONOMIC ANALYSES

5.5 OPTION 4 - INSULATION OF LINES & TANKS

Steam distribution efficiency depends in part on effective insulation of the transport system. Panel Mine was built about 24 years ago, and operated intermittently. As a result, the insulation on steam lines has likely degraded to some extent. The amount missing and condition of the insulation improvements can only remain an area for further detailed investigation by Rio Algom personnel. Infrared scanning is a technique that could be used to detect sections of deteriorated insulation.

Assessing the condition of the leach Pachuca tanks is somewhat simpler. Insulation is not in place at the present time. To simplify the analysis of adding insulation to the tanks, a single evaluation of a 10 cm application is considered. A more detailed optimization analysis of insulating thickness would have to be completed if a program of this sort were selected for detailed study.

The degree of solids sanding out in the tanks complicates analyses of heat losses and the amounts of insulation required. Heat loss surveys[6] estimated tank losses average 900,000 BTU/hr/tank. A clean tank has a shell loss of 300,000 BTU/hr and a sanded tank 150,000 BTU/hr. For this study, it is assumed of the 14 tanks available (12 typically in operation) 7 are sanded and 7 clear. Further investigations are required to confirm the state of the build-up in the tanks and the exhaust gas heat loss contribution. Heat losses are considered to eminate from six clear tanks and six sanded tanks, resulting in a total heat loss of 2.7 x 10^6 BTU/hr. A sanded out tank is shown in Fig. 5.5.1. Insulation is therefore required on the tops of all tanks, the top 4.6 m of 7 tank cylinders, and the upper 9.2 m of the clear tanks. The cost of insulating the required tank surface areas totals about $174,000.

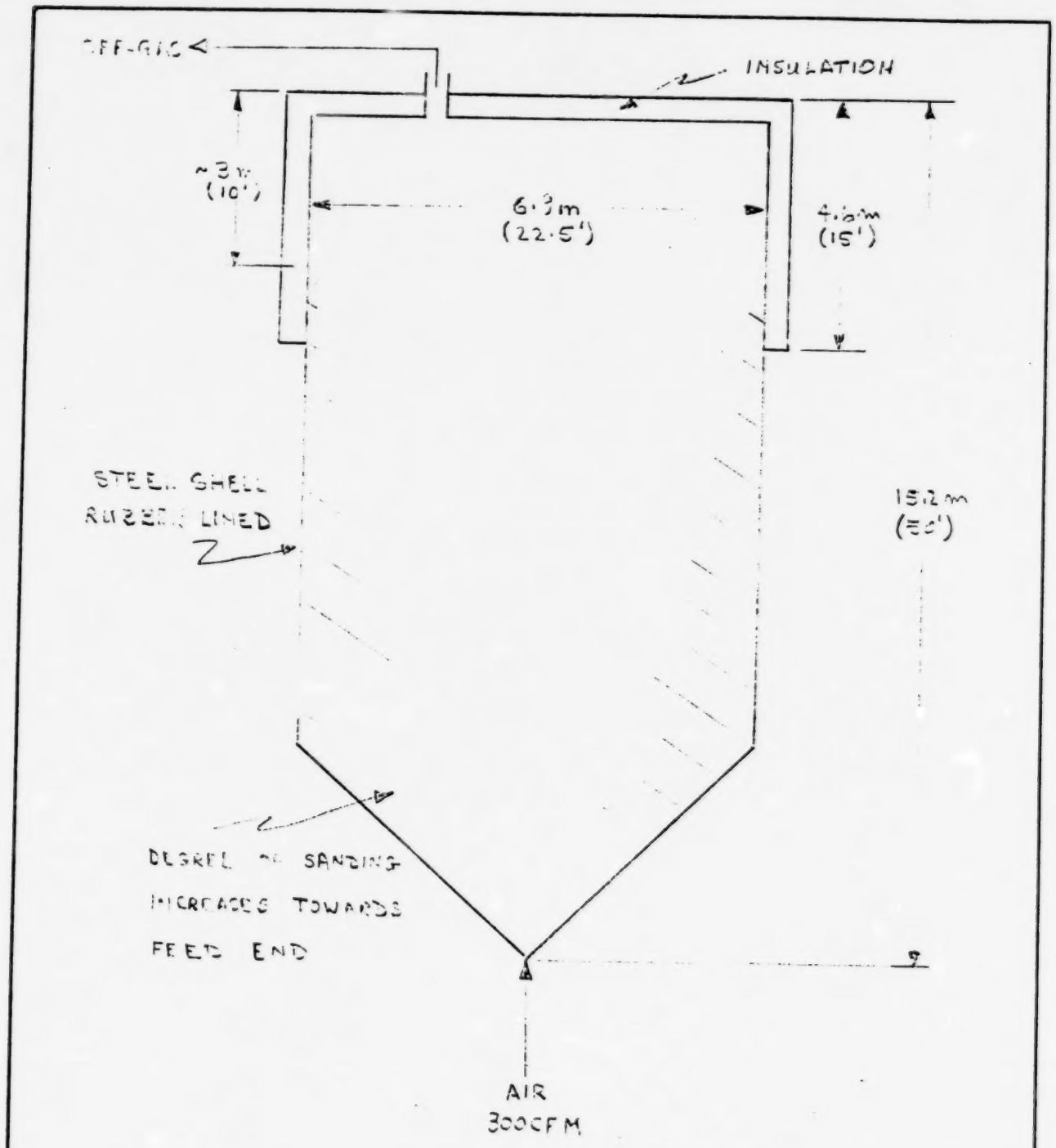

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FIG. 5.5.1 INSULATION ON SANDED PACHUCA TANK

SECTION 5

EFFICIENCY IMPROVEMENTS AND ECONOMIC ANALYSES

5.5 OPTION 4 - INSULATION OF LINES & TANKS

Insulation costs are estimated for fiberglass clad with aluminum. Relative humidity in the mill may preclude the use of fiberglass and favour foam glass or urathane foam which are less sensitive to moisture degradation. Heat transmission is expected to be reduced about 70% with the insulation in place.

Heat savings are estimated to be equivalent to 399,400 kg of oil per year based on an installed cost of insulation of $61.98 per square meter on the sidewalls and $86.08/m^2$ on the tops.

Table 5.5.1 shows the economic analysis covering the tank insulation option. The benefit/cost and payback periods are 1.24 and 29 months respectively.

TABLE 5.5.1

ECONOMIC EVALUATION OF INSULATING PANEL MINE

PACHUCA TANKS WITH 10 CM OF FIBERGLASS INSULATION

Year	Capital Investment	Fuel Saving	Cap. Cost Allowance	Taxable Income	Tax 50%	Cash Flow	Annual Present Value	Total N.P.V.
0	174,000	-	-	-	-	-174,000	-174,000	-174,000
1	-	77,640	77,640	0	0	77,640	69,330	-104,668
2	-	88,743	88,743	-	-	88,743	70,728	-33,940
3	-	101,433	7,617	93,816	46,908	54,525	38,822	+4,882
4	-	115,938	0	115,938	57,969	57,969	36,868	+41,750

Note:

1) Payback Period 29 months

2) Benefit/Cost = 215,748/174,000 = 1.24

3) NPV = net present value

SECTION 5

EFFICIENCY IMPROVEMENTS AND ECONOMIC ANALYSES

5.6 OPTION 5 - MODERNIZATION OF BOILER COMBUSTION CONTROLS

Conversion from coal to oil firing took place in 1977 at Panel Mine. The combustion controls installed at that time of conversion were a basic electro-mechanical type but none the less have provided trouble free service.

Steam drum pressure is used as the principal control parameter. Over the years the mechanical linkage control system developed a degree of backlash or slopiness, mainly due to wear. To bring the combustion control system up-to-date, replacement of the mechanical drive system with new drivers on the fuel, air and atomizing steam valves are considered. This amounts to retaining the basic parallel control mode philosophy while incorporating the improvements described above. A more complex cross limited type of control requiring fuel and air flow measurements would be more expensive and is not considered in this option. The cost of the installed instrumentation package on one boiler is estimated to total about $25,000.(10)

Improvements expected from the introduction of the new controls are difficult to assess without an evaluation program but are not expected to exceed 1% (10) of the fuel used per year.

In addition to the boiler burners which operate at a minimum of 10 to 15% excess air, the combustion chambers are also basically leaky resulting in large flows of ingress or tramp air. In such an instance, it would be impossible to use oxygen in the off-gas to trim the combustion air requirement. Carbon monoxide detection is also not feasible because of the excess air requirement of the boiler burners. The cost of CO detection and trim is about twice the price of oxygen trim control.

SECTION 5

EFFICIENCY IMPROVEMENTS AND ECONOMIC ANALYSES

5.6 OPTION 5 - MODERNIZATION OF BOILER COMBUSTION CONTROLS

With the above shortcomings, an integral part of the combustion system, annual fuel savings are not expected to be very significant. Approximately 35 x 10^3 kg/yr. of oil could be cut from the fuel bill.

Table 5.6.1 shows the economic analysis supporting the installation of more modern control instrumentation. The benefit/cost ratio and payback periods are 0.89 and 52 months respectively.

TABLE 5.6.1

ECONOMIC EVALUATION OF COMBUSTION

CONTROL INSTRUMENTATION MODERNIZATION

Year	Capital Investment	Fuel Saving	Cap. Cost Allowance	Taxable Income	Tax 50%	Cash Flow	Annual Present Value	Total N.P.V.
0	25,000	-	-	-	-	-25,000	-25,000	-25,000
1	-	6,820	6,820	0	0	6,820	6,090	-18,910
2	-	7,795	7,795	0	0	7,795	6,213	-12,697
3	-	8,910	8,910	0	0	8,910	6,344	-6,353
4	-	10,184	1,475	8,709	4,355	5,830	3,708	-2,645

Note:

1) Payback period 52 months

2) Benefit/Cost = 22,355/25,000 = 0.89

3) NPV = net present value

SECTION 5

EFFICIENCY IMPROVEMENTS AND ECONOMIC ANALYSES

5.7 OPTION 6 - PACHUCA HEATING METHOD

Leaching process heat is currently supplied by steam directly injected into the Pachuca tanks. The potential condensate is therefore lost to the leaching slurries. To recover condensate from this system an alternate heating medium could be substituted for the steam. Possible alternatives include air or air/steam mixtures.

Steam to the Pachuca tanks totals 10,000 kg/hr. The heat content is 6,560 Mcal/hr. Substituting air at the same temperature and assuming 100% heat transfer requires an air rate equivalent to 0.76 tank replacements per minute. Such a rate is unacceptably high making air substitution impractical. To circumvent this condition, indirect heating using steam coils either within the tanks or attached externally were considered. External heating suffers from poor heat transfer due to rubber linings in the tanks. Acceptable materials of construction capable of withstanding the extremely abrasive slurry environment are difficult to select. Tips of the steam spargers corrode rapidly especially in tanks with slightly reducing conditions illustrating the nature of the materials problem.

It was concluded that simple methods of recovering condensate from the Pachuca tanks are not feasible. Further investigations were not pursued.

SECTION 5

EFFICIENCY IMPROVEMENTS AND ECONOMIC ANALYSES

5.8 OPTION 7 - BOILER BURNER UP-GRADED

At full capacity, the burners in Panel Mine boilers are estimated to operate in the range of 15 to 20% excess air. This is primarily to prevent soot formation and secondly due to thermal degradation of the burner air flow control registers. An option considering a new burner capable of operating at about 5% excess air requires the installation of a burner, ancillary hardware and fan. Utilizing a burner recently introduced into the North American marketplace, existing controls can be left in place and still permit operations at the tighter excess air specification. The design proposed is a type of axial flow, skewjet atomizer burner produced by *CEA Canada.

Based on past experiences, retrofitting existing boilers with new burners has ben unattractive for units rated at 65,000 lb/hr. steam or less. The unit described above is being marketed to compete at lower production levels.

To estimate the expected savings resulting from installation of the new burner, it is assumed the burner excess air is reduced from 20 to 5%. In addition, reduction in draft and better sealing should permit a reduction of the same amount of tramp air. The savings in fuel is estimated to be 60,612 kg of oil per year. Value of the oil cut from the fuel bill is approximately $11,760 in the first year.

Table 5.8.1 shows the economic analysis supporting the selection of the improved burner option. The benefit/cost ratio and payback periods are 0.89 and 58 months respectively.

*CEA Canada Ltd. is currently introducing this new burner to the North American marketplace and has informally indicated an interest in joining in the monitoring program should one of their burners be installed.

TABLE 5.8.1

ECONOMIC ANALYSIS OF INSTALLING

A LOW EXCESS AIR ECOPAK BURNER

Year	Capital Investment	Fuel Saving	Cap. Cost Allowance	Taxable Income	Tax 50%	Cash Flow	Annual Present Value	Total N.P.V.*
0	39,100	-	-	-	-	-39,100	-39,100	-39,100
1	-	11,760	11,760	0	0	11,760	10,502	-28,600
2	-	13,442	13,442	0	0	13,442	10,713	-17,885
3	-	15,364	6,998	8,366	4,183	11,181	7,961	-9,924
4	-	17,561	0	17,561	8,781	8,781	5,584	-4,340

Note:

1) Payback period 58 months

2) Benefit/Cost = P.V. Savings/Investment = 34,760/39,100 = 0.89

*NPV = net present value

SECTION 5

EFFICIENCY IMPROVEMENTS AND ECONOMIC ANALYSES

5.9 OPTION 8 - COMBUSTION AIR PREHEATING

Option 1 discusses an economizer addition to the Panel Mine boilers. Rather than heating feedwater, combustion efficiency can be improved by preheating combustion air. A gas to gas heat exchanger would be required from which the F.D. fan would draw combustion air. However, two shortcomings exist in the present system. The maximum operating temperature of the forced draft fan is below the air temperature required to make a marked improvement in efficiency. In addition, the combustion throat is too small to permit passage of the necessary combustion air without an unacceptable pressure drop. To circumvent these problems, wholesale charges of the boiler fan and burner arrangement are needed as well as the heat exchanger. The costs total more than the economizer option and are estimated to represent an unacceptably long payback period. As such, further work on this option was not carried out.

APPENDIX A

LIST OF REFERENCES

1) Charles Turner & Associates, Specification for Mechanical Scope of Work - Panel Project Boiler Plant, June 1977.

2) R.J. Reed, Combustion Handbook, 2nd ed. pub. by North American Manufacturing Co., Cleveland, 1978.

3) Babcock & Wilcox, Steam/Its Generation and Use, pub. by B & W, New York, 1978.

4) Telephone conversation - Foster Wheeler, Toronto

5) Communication with Thermaco Engineering, Streetsville, Ont.

6) Telephone communication with John Bellanger, Rio Algom Process Technology

7) CEA Canada Ltd. - descriptive literature describing the burners installed at Panel Mine.

8) CEA Canada Ltd. - descriptive literature describing their new CEA 6001 ECOPAK burner.

9) Tranter Canada Ltd. - quote on Kentube Retromiser package for feedwater heating.

10) Telephone conversation with Bailey Controls, Toronto.

11) Telephone conversation with CHARMAC Distributing, Barrie.

APPENDIX B

BOILER FUEL CHARACTERISTICS

Table B1 shows the available data on Bunker C oil currently being used to fire the boilers at Panel Mine.

TABLE B1

SUMMARY OF BUNKER C OIL CHARACTERISTICS

Item	Fuel Data					
Source	Ontario Hydro - Lennox surplus					
Composition*	C	H	0	N	S	Vppm
	87	11.08	0.5	0.5	1.09	76
Gross Calorific Value	176,000 BTU/I gal.					
Calculated Net Calorific Value	9994 kcal/kg					
Cost Delivered	82¢/I gal.					
S.G. (60°F)	0.928					
API° (60°F)	21					
Viscosity (CTS 50°C)	70.6					
Flash Point (°C)	98					

*Estimated from API° value according to reference (2)

APPENDIX C

FUEL CONSUMPTION AND STEAM GENERATION - PANEL MINE BOILERHOUSE, 1981

Table C1 illustrates the variation in steam production from all boilers on a monthly basis during 1981.

TABLE C1

SUMMARY OF BUNKER C OIL CONSUMPTION AND STEAM GENERATION IN 1981 - THREE BOILER OPERATION PANEL MINE

Month	Oil/Month*		Steam/Month		Steam/Oil
	I. Gal.	kg x 10^3	lb x 10^6	kg x 10^6	kg/kg
January	277,627	1161.0	40.20	18.27	15.74
February	216,106	903.7	36.69	16.81	18.6
March	295,386	1235.2	36.98	16.55	13.40
April	246,300	1030.0	36.41	16.55	16.06
May	202,771	848.0	29.71	13.51	15.96
June	152,197	636.5	23.01	10.46	16.43
July	107,203	448.3	16.42	7.46	16.6
August			28.63	13.01	16.3
September	134,685	563.2	21.19	9.63	17.09
October	224,793	940.0	34.63	15.74	16.75
November	243,868	1019.8	40.00	18.18	17.83
December	278,362	1164.1	39.61	18.00	15.46
Annual Total	2,523x10^3	10,549			
Average					16.35

*Bookkeeping months set by warehouse accountants - not strict calendar months.

POOR

QUALITY

ORIGINAL